

TRANSPORTATION

Marshall Space Flight Center CDDF Success Story Number 1

Robust Low-Cost Aerospike Combustion Chamber

Next-generation, regeneratively cooled rocket engines will require materials that can withstand high temperatures while retaining high thermal conductivity. A Center Director's Discretionary Fund (CDDF) project was initiated to develop and demonstrate a robust low-cost Aerospike combustion liner, utilizing vacuum plasma spray (VPS) functional gradient coating techniques, developed in the MSFC Microgravity Program. The thermal barrier coatings combined with the high-temperature properties of Cu-8Cr-4Nb, developed at LeRC, will further enhance the operating life and performance of liquid rocket engines. Thermal analysis showed that a 0.0035-inch NiCrAlY coating applied to Cu-8Cr-4Nb will lower the operating temperature of the liner by 200 °F, increasing liner life and reducing maintenance costs. Parameters were developed, bulk Cu-8Cr-4Nb material was VPS deposited onto cylindrical mandrels, and properties specimens were machined from the VPS- formed shell. The heat treated VPS tensile specimens had a density 99.2 percent of theoretical.

Testing showed that the ultimate tensile strength (UTS) of VPS Cu-8Cr-4Nb at 1,000 °F was 197 mega Pascal (MPa) or 50 percent stronger at operating temperature than the X-33 and SSME baseline alloy, NARloy-Z. Yield strength was 179 MPa, an 84 percent improvement for the VPS Cu-8Cr-4Nb. This work demonstrated that VPS Cu-8Cr-4Nb offers significant properties improvement over the existing alloy material, NARloy-Z, and is very timely, taking the fact that it is questionable that NARloy-Z is strong enough to contain the thrust needed to lift RLV into lower Earth orbit. A Cu-8Cr-4Nb liner has been VPS sprayed with the NiCrAlY functional gradient coating, to demonstrate a 200 °F drop in liner temperature, giving longer combustion chamber operating life and reduced maintenance costs. The heat treated and machined VPS Cu-8Cr-4Nb liner will be HIP brazed in a Lewis Research Center spoolpiece support jacket and hot fire tested this summer.